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SKILLMAP – A SOCIAL SOFTWARE FOR KNOWLEDGE MANAGEMENT – FROM CONCEPT TO PROOF

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Tobias Lattke¹

Abstract

skillMap serves the demands of 3rd generation KM for unstructured and human-centred approaches and is based on the Web 2.0 – concept. It combines a social network with a semantic network of skills. A visualization of the combined graphs serves as user-interface. After describing the technical implementation of the skillMap, we argue that the skillMap offers levels of variety, autonomy, creative chaos, and redundancy that are present in successful social movements of the web and fuel users' intrinsic motivation. User evaluation results show that the positive perception of the user interface co-occurs with user expressions of enjoyment and curiosity.

1. Introduction

Developments towards a knowledge society [19] and the aim of the European Union to become the world's leading knowledge-based economy [3] underline the key role of knowledge as “the one sure source of lasting competitive advantage“ [20, p. 29]. Yet despite this insight, knowledge management systems (KMS) have failed to fulfil the organizational promises with which they were first introduced. Codification of knowledge in databases accompanied by a lack of personalization have led to the creation of data and information graveyards that hardly bear much value for companies. Those who carry knowledge seem to be little motivated to contribute it. If they do, their documents are difficult to find. All in all, current platforms do not stimulate personal knowledge sharing nor self-presentation as experts.

With the advent of Web 2.0 and a potential translation of this concept to enterprise environments [17], hope has climaxed that company wisdom may be captured after all by embracing new collaborative technologies. Examples, such as Wikipedia, provide proof that people do participate in knowledge creation [18]. And social network platforms, such as Facebook, help to identify those who carry knowledge. With ‘Enterprise 2.0’ initiatives companies now try to embed these new collaborative platform schemes into their Intranets.

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The skillMap system was designed to support companies in their 'Enterprise 2.0' initiatives by addressing the very shortcomings of traditional knowledge management systems: user motivation to participate and facilitation of knowledge search. *skillMap* aims to motivate participation and facilitate search by offering an innovative, animated network visualization for knowledge display and search. It displays people's skills and personal relations on one graphical level (see Figure 1). By combining people and their shared knowledge entities in one view skillMap could be described as a visual manifestation of 'ba', the concept of shared context propagated by Nonaka and Konno [12] and recognized as so vital for knowledge creation. By departing from the classical 2-dimensional interaction paradigm for knowledge organization and instead propagating a navigable map structure for knowledge management, the software responds to insights from psychology that people mentally organize their knowledge in networks [11]. Within seconds the application gives answers to the questions: Who knows what in an organization? And who knows whom? It is a solution response to McAfee who stated in his seminal article on Enterprise 2.0: „It starts to seem odd that companies and technologists ever proposed highly structured KM systems to capture highly unstructured knowledge work“ [10, p. 26].

skillMap has been developed at the Institute of Information Systems at Humboldt University Berlin in the context of the Berlin Research Centre on Internet Economics (InterVal). In 2007, SUN Microsystems was won as the first paying customer to test early versions of the software. In July 2008, skillMap GmbH has been founded and now markets the software.

2. The skillMap System

2.1 skillMap's System Structure and User Interface

skillMap consists of two interlinked components: A social network graph of individuals and a skill graph (semi-lattice) of individuals' interests or competencies. Individuals and skills are represented as nodes in the two graphs, interconnected through edges. Every individual and every skill has a freely definable number of semantic attributes. For example, for every person we can define attributes that serve to describe her, search for her or filter for her (i.e. her affiliation, her location).

Authorized members of a skillMap (who authenticate themselves via a password mechanism) are encouraged to freely edit the skill graph ('skill inventory') of their group, add skills they see missing or re-arrange skill hierarchies. They can equally change personal attributes. Authorized users are *by default all* people invited to and displayed in a skillMap. The result is a self-assessment of the entire organization and the expertise of its members. skillMaps are thus foreseen to serve closed groups that have a mutual trust base.

When skillMap is started through Java Web Start, the user is confronted with a two-sided graphical user interface (GUI). On the left, a network is displayed that can be edited and navigated. On the right side of the screen, static information about the network's content is displayed, in particular users' social attributes. The networks displayed have the relatively unique property that they consist of *two* interlinked graphs: the social network and the skill inventory graph. The social network graph contains the names and photographs of group members. By visualizing persons that are connected to the same expertise node but have no social edge between them, the user can identify members of the organization that work in the same field without knowing each other. This can reduce redundant work and increase organizational performance. Algorithms for automating this task have been developed and tested [11].

Figure 1 shows the skillMap GUI. Skills are visualized in tree format. However, this does not imply a directed graph. Instead, it is possible to create any kind of connection between skills (i.e. 'is equal to' or 'is similar to'). In this way, the skill inventory is also able to capture redundancies. It is a structured and contextualized tagging space in which tags become nodes that have edges between each other. Any editing, adding or changing of skill tags is initiated directly in the GUI by a simple right-click on a respective skill node. Zooming into the graph structure can facilitate tagging in the person-, the skill-, or in the combined map. The size of the respective maps can be adjusted from 25% to 100%. The social network can be displayed with different degrees of depths and the skill graph can be navigated similar to a hierarchical ladder where the steps can be opened and closed upon demand.

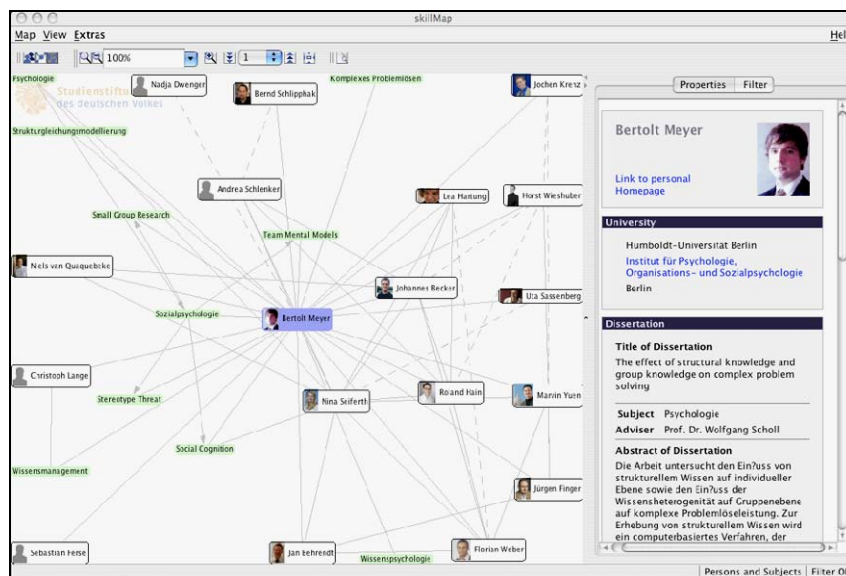


Figure 1: skillMap System graphical user interface (GUI)

Finally, to enable search, the skillMap menu contains a search function. Search can be conducted for persons and skills. Any keyword (or part of a keyword) that can be found in the skillMap already is immediately displayed. In this way users find what they look for in a few seconds and also see whether there are redundant entries. An alternative to keyword-based search is to interactively navigate the skillMap.

2.2 skillMap's technical architecture

The skillMap system is based on a 3-tier architecture. The client (presentation layer) is a Rich Internet Application (RIA) that runs in a Java Runtime Environment (JRE) accessible through Java Web Start. JRE is a platform independent standard that allows skillMap to be run on most systems. On the client side the application is programmed in Java. The GUI is based on Java Swing and the free libraries JGoodies Looks and JGoodies Forms [9]. It is complemented by the prefuse library which is particularly elaborate in the visualization of and interaction with graphs [7]. Prefuse offers various layout algorithms as well as navigation and interaction technologies for dynamically animated visualization [7]. In order to ensure response behaviour for skillMap that is similar to a desktop application a copy of the prefuse datamodel (which holds graphs, nodes and edges) sits on the client side. It is downloaded once at the beginning of a user session. When users make changes to their local graphs (decentralized data models) these changes are transmitted via XML-RPC³ to the backend

³ Extensible Markup Language Remote Procedure Call

server where they are queued to adjust the central data-model. Equally, user changes are immediately displayed in the client.

The middle layer of the skillMap architecture, the application layer, is based on a server that is embedded as a servlet into a servlet container (Tomcat). It uses the *prefuse* data structure to model and change the graph, control changes and restrictions and conduct any further analyses. Furthermore, the server manages skillMap users, their profiles and privacy preferences. The data it contains can be imported or exported via an XGMML-format⁴. XGMML is an XML data format that is based on the GML, a standardized graph modelling language [15]. However, the main data exchange interface is facing the bottom layer, the database layer. Here, the skillMap application layer communicates with an SQL-database via a persistency layer framework and JDBC. This ensures that changes to the database do not require us to constantly change the server or the datamodels we use. Figure 2 gives an overview of the skillMap software architecture.

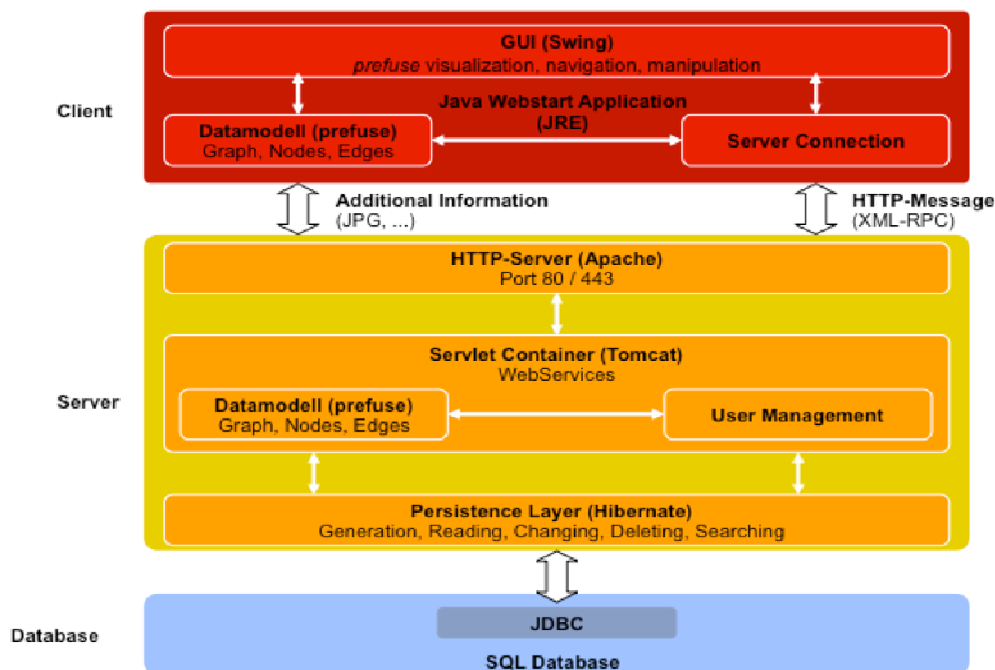


Figure 2: skillMap architecture

3. The skillMap as an Enterprise 2.0 Knowledge Management System

The aim of KMS is to support the knowledge processes (1) creation, (2) storage/retrieval, (3) transfer and (4) application [1]. Typically, IS scholars analyse KM systems' functionality with a view to these aims [16] and/or collect the technical parameters of KM infrastructures to meet them [5, 6]. Systems are described and compared on the basis of their technical architecture (operating system, protocols used, database management, interfaces, import/export functions), their user management and security mechanisms (authentication, authorization, central rights' management, etc.), their communication and collaboration capabilities (RSS, IM, Presence Indicators, Wikis, Forums, Blogs, Screensharing, etc.), their search capabilities (fulltext, keywords, metadata, semantic information, etc.), their content creation and management capabilities (versioning functions, log functions, bookmarks,

⁴ extensible Graph Markup and Modelling Language

knowledge structures), their output functions (personalization, multi-channel output, multi-language output, document conversion) and their social networking capabilities (chat, discussion boards, presence, feedback, activity display, yellow pages, etc.). Yet, these functionalities hardly serve to uncover the real benefits of a system such as skillMap. Indeed, many system features have become hygiene factors for systems' success. Furthermore, the existence of a functionality says nothing about its usability, quality or ability to advance an organization. We therefore propose a complementary way to tackle KMS requirements. By combining the thoughts of leading KM scholars and Web 2.0 visionaries we identify key levers for knowledge creation and sharing for 3rd generation knowledge management systems, discuss how technology can support them and then present skillMap functionality in the light of these arguments.

3rd generation KM requirements can be deducted from the Web 2.0 phenomenon, which is currently regarded as the most impressive environment of knowledge creation and sharing. According to technorati.com, over 15 million blogs are actively maintained and as of April 2008, Wikipedia attracts 683 million visitors annually reading over 10 million articles that are written collaboratively by over 75.000 contributors. In Web 2.0's Meme Map, Tim O'Reilly excavates the drivers of these knowledge activities, some of which are social (radical trust in users, participation, decentralization) and some of which are technical in nature (tagging, rich user experience). Many points of the Web 2.0's Meme Map have equally been raised by Nonaka and Takeuchi [20]. In their seminal work on KM, they accumulate a number of enabling conditions that foster 3rd generation knowledge creation and sharing in companies. These include: intention, autonomy, variety, creative chaos and redundancy.

Intention: At the outset of knowledge creation it is necessary to have a working definition, a clear concept and intention of *what kind* of knowledge should be developed in an organisation [20]. The intention, for example, to create an encyclopaedia, needs to be clear in order for contributors and beneficiaries to know what and how to contribute, or what to search for. Many authors agree that a shared understanding of the collective knowledge base is needed for effective KM [1, 4, 12]. A first characteristic for a 3rd generation KMS should therefore be to successfully communicate to users the knowledge concept of the deploying organization and to provide guidelines and affordances for knowledge creation that enforce this concept.

skillMaps are ideal to communicate the intention of why people join forces, because they are purpose oriented knowledge structures. Their purpose is uniquely mirrored in the root skill of a map's skill inventory. For example, employees of InterVal were joined together in a skillMap the root of which was called 'Internet economics'. Naming the root of a skill inventory and defining the first few layers of skills is an exercise that forces skillMap initiators to question the intention of the groups they manage. And communication of the root to skillMap participants is a signal that creates a shared understanding of the knowledge base. Moreover, when introducing skillMaps, a decision must be taken on how members' adherence to certain skills are defined and what kind of relationships are sought for display. Initiators of a skillMap design affordances on the basis of which later skillMap members are allowed to state skills and relationships. For example, the InterVal skillMap only allowed members to display a skill if they had published at least one article on the respective knowledge domain. Equally, a relationship with other InterVal employees could only be claimed if they had worked together on a publication as co-authors. As a result, the skillMap displayed real competencies of InterVal employees and proven communities of practice.

Autonomy: "Wikipedia...is a radical experiment in trust" describes [14] the fact that anyone on earth is admitted to contribute to the online encyclopaedia. And he attributes much of the

project's success to this attitude of 'radical trust'. Corporate hierarchies and the KMS that support them, in contrast, have not been built to incorporate high levels of trust into a decentralized work force when it comes to knowledge creation and sharing. Lower level employees are more seen as experts in the area covered by their job description. As a result, traditional KM- and skill systems are nerved with clear rules on who may contribute what. Knowledge is often structured alongside the functional expectations of HR departments. However, [20] state: "autonomous individuals and groups in knowledge creating companies set their task boundaries by themselves." A further characteristic of KMS should therefore be to encourage autonomous knowledge creation and contributions *beyond* corporate functions, hierarchies and job descriptions (provided that management agrees).

skillMap's visualization dissolves any hierarchical structure that may reside in the organisational hierarchy of the institution introducing the tool. Thus, it departs from the functional definitions and skill ontologies of HR departments and relies on skillMap members' perceptions of what they are really doing and knowing. As a result, much trust is put into skillMap members to rightfully mirror their work, experiences and knowledge in the skill inventory. Policies and affordances can be integrated in a map to ensure that not everybody claims to know (or work on) everything.

Variety: Variety propagates the free flow of information and negates the common practice of limited access rights to knowledge sources. "To maximize variety, everyone in the organization should be assured of the fastest access to the broadest variety of necessary information, going through the fewest steps" [20, p. 79]. Facilitating search by building links that point to the right sources or allowing for the free creation of tags that better characterize content from multiple viewpoints are certainly some key 'SLATES' [10] to support variety and foster transparency. But at the same time, variety can also cause individuals to be overwhelmed by information. Traditional document management systems tend to bury the variety of existing knowledge in the depths of database folder structures. To come to the surface knowledge objects need to be laboriously sought digging into unknown and inflexible, often cryptic knowledge hierarchies or painstakingly use keyword-based search queries. skillMap, in contrast, surfaces the knowledge variety of an organisation. skillInventories and the documents attached to skill-nodes visualize the variety of knowledge that is existing. Knowledge objects, such as documents, are brought to the forefront of the interface, they can be viewed with one click on a skillnode and they can be more easily found due to the context provided through skillMaps' edge structure.

Creative Chaos: Takeuchi and Nonaka describe creative chaos as the "continuous process of questioning and reconsidering existing premises by individual members of the organisation" [20, p. 74]. O'Reilly refers to a similar concept when naming 'participation' as one key element of the Web 2.0 meme [14]. KMS must therefore encourage participation. Embracing collaborative technologies such as wikis or blogs is one way to do so. But in addition to such functionalities, participation may also be triggered by users' personal outcome expectations [21]. Having fun in interacting with the system (i.e. because it looks good), earning reputation (i.e. because it provides feedback), exercising impression management (i.e. because it allows for self-presentation), learning something through it (i.e. because it is well maintained by knowledge-shepards) or gaining social contacts (i.e. because peers are identified) are characteristics which can be built into KMS to motivate contributions. In skillMap's case the joint editing of a group's knowledge structure in the skill inventory certainly allows for some creative chaos. Participation is thus a key element of skillMaps' use. The degree to which the skillMap technology is capable to stimulate participation though is a matter of how well the

tool taps into the motivation patterns of the group it represents. Section 4.3 therefore reports on how well skillMap is perceived by one of its first trial user groups.

Redundancy: Finally, Takeuchi and Nonaka propagate redundancy as an important condition for knowledge creation. “Redundancy is the existence of information that goes beyond the immediate operational requirement or organizational need...(an) intentional overlapping of information about business activities” [20, p. 76]. The notion of redundancy is also reflected in the call for ‘tagging not taxonomy’ and the idea of a ‘folksonomy’ [14]. The idea is that knowledge structures and knowledge entities are not pre-determined, but can grow dynamically and be enriched through contributions from different angles. In contrast, most KMS or corporate systems generally strive for well-defined MAPs [13] and clear indexing where no room is left for interpretation and knowledge is classified. Equally, knowledge retrieval visions, such as those incorporated in the semantic web, foresee pre-defined ontologies as the way forward and thus run counter to the idea of folksonomy.

Redundancy is certainly a trait deeply embedded in skillMap’s philosophy. The skill inventory allows for multiple naming of the same knowledge object. Ideally the co-existence of different names for the same thing is uncovered, because knowledge objects tend to be placed in the same area of the knowledge map. If this is not the case, then it is the search function that uncovers the pre-existence of a knowledge object. Users have the option to either link a knowledge object to multiple other areas (nodes) of the map, equalize two knowledge nodes that are named differently or state any connection between them. Users are thus completely free to treat redundancies as they feel is sensible. The benefit of this proceeding is that anyone can find himself mirrored in the knowledge structure, as one feels comfortable.

4. Proof of concept

4.1. Performance tests

One dimension of the proof-of-concept of an IS application is its faultless operation. For the time being, we assume that the skillMap application could be used in large knowledge organisations with up to 2500 clients, 5% of which may be accessing the application simultaneously. Table 1 summarizes performance test results for an increasing number of clients for which application access was simulated.

Table 1: Performance test results for fictive skillMap deployments

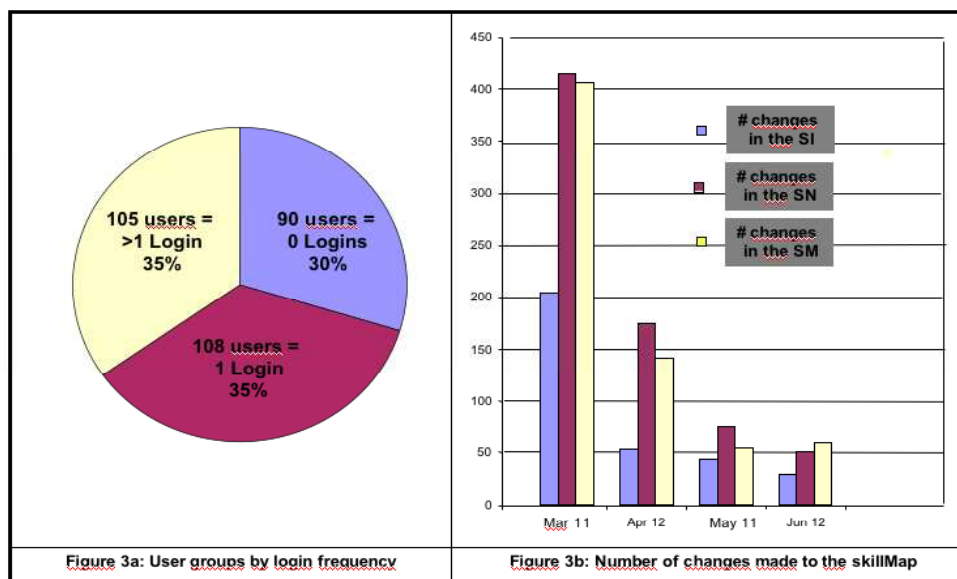
Number of skillmap clients in a deploying organisation	Number of clients simultaneously downloading the skillMap graph at session start	Average time (t) in seconds to download the graph	Number of errors when downloading the graph	Average application response time (t) in seconds when editing skillMap	Number of errors when editing the skillMap
40	2	1,09	0	0,06	0
150	8	3,46	0	0,18	0
300	15	7,55	0	0,34	0
600	30	23,25	0	1,14	0
1000	50	50,67	0	2,45	0
1500	75	57,99	0	2,94	0
2000	100	79,73	0	4,08	0
2500	125	98,79	0	5,30	0

The simulation was run on a server with an Intel Pentium 4 Dual Core CPU (2.8 GHz) and 1 GB RAM, running the Linux distribution Ubuntu (Kernel 2.6.15). As can be seen from table

1 the application produces no errors, neither when loading the initial graph nor when editing. Response times, in contrast, decrease as the number of clients increases. When more than 30 users access the application at the very *same second* latency times of over 1 second for network changes and 30 seconds for the application launch are observed. Both of these performance challenges are currently addressed through the development of a decentralized server structure that is capable to balance the load of graph management transactions.

4.2. skillMap adoption at a client organization

A test-installation of the skillMap was launched in March 2007 for the recipients of a Ph.D. scholarship from the German National Academic Foundation. 303 users registered and created a skill inventory that currently consists of 693 skill nodes and 763 edges between them. On average, users make eight changes per day to the network. Figures 3a and b summarize how the skillMap is adopted in the organisation. 35% of the user base are actively using the skillMap (see Figure 3a). When users are coming back to the skillMap it is interesting to observe what kind of changes they are making. Changes to the skill inventory are the least prominent among editing transactions. Probably skill trees start to reach a point of perfection where users see decreasing marginal utility from further optimizing. For the first three out of four months of deployment expanding and editing of the social network is causing most of the transactions, closely followed by the editing of one's own skills. For all kinds of changes a decrease of editing activity can be observed as the sophistication of the network matures.



4.3 User evaluation of skillMap

In order to empirically test users' perception of the skillMap, we focused on two intended benefits of the skillMap: A rich user experience through the GUI and the activation of intrinsic motives such as fun and curiosity. As stated above, the activation of such intrinsic motives is one of the core success factors for social movements [8] and for the success of Web 2.0 sites. A rich user experience is seen as one of its conditions. Operationalization of the user experience and of GUI enjoyment were based on the extended KM Acceptance model [2] (which again is based on the well-known TAM). It resulted in 11 items with references to enjoyment and experience [8]. These were presented with a seven-point Likert scale to 115 users who completed the evaluation questionnaire.

In order to test the assumption that perceived attractiveness of the skillMap's GUI and perceived fun in system usage can be seen as two underlying features of system usage that influence each other, a factor analysis with principal component analysis was performed (see Table 2). Two factors account for 62.2% of observed variance: Factor 1 captures enjoyment and interest. Factor 2 encompasses the perception of skillMap's GUI as lively, enjoyable and superior to the organisations' regular intranet. A challenge for users seems to be that the skillMap is sometimes difficult to grasp. Thus, two distinct underlying components, enjoyment and GUI, exist that are interrelated: the two factors correlate at $r = .50$. All items exhibit an average scale score above 3.5 indicating user agreement to all of them. Thus, users perceive the skillMap as fun to use and label its GUI as enjoyable, although this seems to come at the price that its display is sometimes difficult to grasp.

Table 2: Pattern matrix of the rotated factor analysis (oblimin rotation, $N = 115$) and descriptive statistics.

<i>Item</i>	<i>Factor 1</i>	<i>Factor 2</i>	<i>Mean</i>	<i>SD</i>
I enjoy using the skillMap	.16	.78	4.05	1.67
I enjoy exploring the networks	.07	.83	4.16	1.57
I discover other persons of interest	-.04	.71	3.90	1.63
The skillMap fuels my curiosity	-.05	.86	4.40	1.54
Working with the skillMap is a pleasure	.80	.11	4.03	1.42
The skillMap delivers a beautiful visualization	.92	-.15	4.96	1.59
The skillMap's GUI is more attractive than our intranet's GUI	.80	-.02	4.50	1.85
The person network in the skillMap creates a lively impression	.53	.16	4.32	1.58
The graphic representation is difficult to grasp	.65	.05	4.05	1.80

Note. Items were presented with a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

5. Conclusion

The German 'Business Informatics' discipline is emphasizing the importance of building prototypes and being close to technology deployed in the real-world. This article presents a software called skillMap that was built as a proposition for how 3rd generation knowledge management tools could function. The software is presented from a technical angel and it is discussed in what respect it servers the ideas of 3rd generation knowledge management. Furthermore, the user evaluation demonstrates that the core feature of the skillMap, its innovative GUI, co-occurs with perceived fun and joy in system usage. This finding demonstrates that the skillMap offers a rich user experience – one of the core demands of Web 2.0 technologies. The fun that users experience fuels their intrinsic motivation to contribute to it. We therefore believe that skillMap bears the opportunity to channel some of the success of web-based social sites into the organisational context. Broader market success and commercial uptake will show whether we will be proved correct.

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